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SPIDERS AND THEIR PREY IN MASSACHUSETTS CRANBERRY BOGS

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ABSTRACT. Spiders from a total of 24 genera and eight families that possessed prey were collected using direct observation and sweep sampling during a survey of seven stands of wild (four sites) and abandoned (three sites) cranberry bogs in Massachusetts. Over all sites, 7009 spiders were inspected and 2.7% of all individuals possessed prey. At the wild bogs, Lycosidae and Araneidae were most commonly collected and at the abandoned bogs, Oxyopidae and Tetragnathidae were most common. A total of 11 orders of prey was observed and small Diptera (39.4% of total) (particularly Chironimidae), Collembola (18.6%), Homoptera (11.7%) (particularly Cicadellidae), and small Hymenoptera (9%) were the most common prey items. For all sites, three species of spider [*Pardosa saxatilis* Hentz (Lycosidae), *Oxyopes salticus* Hentz (Oxyopidae), and *Tetragnatha laboriosa* Hentz (Tetragnathidae)] represented 58% (109/188) of all specimens collected with prey. Sixty-seven percent of the prey recovered from *P. saxatilis* were Diptera or Collembola; another 20% were identified as Homoptera and Araneae. Collembola (35%) and Diptera (24%) were the dominant prey captured by *O. salticus,* and no predation on spiders by this species was observed. The majority of *T. laboriosa* with prey possessed chironomids (63%) or homopterans (17%). Dvac® samples of vegetation, taken during the study to determine levels of the total potential prey, showed that the most abundant orders were Collembola, Diptera, and Araneae and Hymenoptera and that the number and type of prey taken by spiders fluctuated with the relative abundance of potential prey.

Spiders (Arachnida, Araneae) are often the most ubiquitous and diverse insectivores in terrestrial ecosystems, exhibiting a variety of foraging strategies and prey preferences. Numerous surveys of spiders and their arthropod prey have been conducted in managed crop ecosystems, showing that spiders constitute a significant proportion of the predator guild (Young & Edwards 1990; Nyffeler et al. 1994); and in some systems, spiders are believed to contribute to the biological control of arthropod pests (Riechert & Lockley 1984; Nyffeler & Benz 1987; Wise 1993). Unfortunately, in comparison to undisturbed or natural environments, it is not surprising that it has also been shown that typical agroecosystems have considerably lower species diversity (Luczak 1975) and mean spider densities (Nyffeler et al., 1994). For example, in field crops, spider populations are adversely affected by intensive disturbances, including cultivation, mowing, harvesting and pesticide use.

The cranberry, *Vaccinium macrocarpon* Aiton, is a perennial vine that is native to wetlands in the northern regions of North America. On wild and abandoned stands of cranberry, a great number of spiders can be found, but no investigations of their predatory role have been undertaken. In this article, we report the results of a study of spiders on wild and abandoned cranberry beds. We did not work on managed beds because we wished to determine the maximum levels of spider activity in the absence of extensive disturbances, particularly flooding and pesticide applications, which are typical on the majority of commercial bogs. The main objectives of this study were to identify the most abundant species of spiders and the prey of these spiders in stands of cranberry.

METHODS

Study sites.—In 1992, surveys of spiders with prey items in their chelicerae were carried out in seven non-commercial cranberry bogs in eastern Massachusetts ranging in size from 0.2 to 1.2 ha. Bogs were classified as either "wild" or "abandoned" and were dominated by cranberry vines. The four wild bog sites were located in Sandwich (Sandy Neck), Truro (High Head), and Provincetown (Herring Cove and Mt. Ararat) in depressions be-

tween sand dunes. In addition to cranberry vines, other vegetation at these sites included Sphagnum moss, bayberry (*Myrica pennsylvanica* Mirbel), bog orchids (*Habernaria* spp.), round-leaved (*Drosera rotundifolia* L.) and thread-leaved (*Drosera filiformis* Raf.) sundews, poison ivy (*Rhus radicans* L.), various sedges, grasses and rushes, and other herbaceous and woody plants commonly found in undisturbed bog habitats in the region. The three abandoned bogs, located in Sandwich (Windmill) and Rochester (Mello 1 and Mello 2), were originally established for commercial cranberry production but were unmanaged for at least five years before this survey. Abandoned bogs had thick mats of cranberry vines and Sphagnum moss interspersed with grasses, brambles (*Rubus* spp.), poison ivy, small flowering shrubs, and saplings of the early successional tree species found in adjacent wooded habitats (including *Acer rubrum* L., *Pinus strobus* L., *Populus* spp., and *Betula* spp.).

Bogs were considered to be composed of three overlapping strata: (1) ground surface beneath the vines, (2) dense cranberry vines, and (3) taller vegetation (composed of grasses, bayberry bushes, and tree saplings). As hunting spiders generally forage on vegetation and web-builders trap prey from the air, we hypothesized that spiders within these strata would encounter and capture arthropod prey from the arthropod orders most commonly located there.

Collection methods.—Surveys of spiders and their prey were conducted at all wild and abandoned bogs on alternate weeks between 1 June–28 August 1992. During this period, seven surveys were made at each site. Direct observation and sweep sampling to obtain spiders with prey were conducted at the sites between 0930–1530 h, weather permitting. The first sampling method employed after arrival at a study site was direct observation. We divided each site into three parts of similar size, dependent on the total size of each site, using physical landmarks such as shrubs, trees, bog ditches, etc. Within each section, sampling was carried out by three observers who walked random paths for an hour. Bog vegetation was visually searched for spiders, which were aspirated into clear, 30 ml cups and inspected for the presence of prey in their mouthparts. If a spider possessed a prey item, alcohol was added to the cup to kill the spider; and both spider and prey were brought back to the laboratory for identification. If a spider did not possess a prey item, the inspection event was recorded on a hand-held counter and the spider was released.

Next, 30 sets of five random sweeps were performed using a circular, 27.5 cm diameter cloth net, with each person sampling one-third of the bog. After five sweeps, the contents of the net were emptied into a light-colored dish pan; and spiders were quickly aspirated into cups and their mouth parts checked for prey. Spiders with and without prey were treated in the same manner as those captured during direct observation. Before leaving a site, 25 randomly-selected 0.20 m^2 point samples of the arthropod fauna were obtained using a Dvac® (Dvac; Ventura, California) suction device (Dietrick 1961); and contents were placed in cyanide jars and transported back to the laboratory for identification. On several occasions, bogs were saturated with water, preventing use of the Dvac® and causing arthropod samples at some sites to be discontinuous.

In addition to the seven-week surveys, two extra direct observation examinations were conducted between normally-scheduled survey weeks at each of two abandoned bogs (Mello 1 and Mello 2) and two wild bogs (Herring Cove and Mt. Ararat). Direct observations were performed in exactly the same manner as previously described; however, no sweep net or Dvac samples were taken.

Identifications.—The first author identified all spider specimens collected with prey in the laboratory to genus, and species when possible, using Kaston (1981). Voucher specimens preserved in 70% ethanol were sent to the American Museum of Natural History for confirmation and have been deposited in the University of Massachusetts entomology collection. Prey items removed from the mouth parts of spiders were identified to order. A few prey remains that were not identifiable were discarded and the capture event removed from the data record for the site where the spider with prey was collected. Arthropods from Dvac® samples were identified to order and preserved in 70% ethanol.

Additional field trial.—In 1993, we compared the effectiveness of the direct observation method we employed during 1992 with

Table 1.—Percentage of spiders collected with prey in wild or abandoned cranberry bogs in 1992.

Bog sites (ha)	No. spiders inspected	No. spiders with prey	% spiders with prey
Wild			
High Head (0.5)	947	37	3.9
Herring Cove (1.2)	962	23	2.4
Mt. Ararat (0.2)	968	36	3.7
Sandy Neck (0.8)	713	22	3.1
All wild bogs	3590	118	3.3
Abandoned			
Mello 1 (1.2)	982	23	2.3
Mello 2 (1.2)	1663	28	1.7
Windmill (1.2)	774	19	2.5
All abandoned bogs	3419	70	2.1
Total—all bog sites	7009	188	2.7

the "drunkard's walk" (Southwood 1978) for capturing spiders with prey in the cranberry system. The latter method required the establishment of a centered transect line at a site and use of a random numbers table to select discrete areas where direct observation was performed. Two people with observation experience from the 1992 survey conducted the collection comparison. Once a point was selected, the spiders present within a 0.9 m radius were individually captured and inspected during a 15 min period. A total of four individual points was selected by each observer during an hour. Three wild bogs from the 1992 study (Mt. Ararat, Herring Cove, and Sandy Neck) were selected for the comparison of the two sampling methods. Each site was surveyed weekly using both methods between 21 July–12 August. A Wilcoxon signed rank test was used to compare the number of spiders inspected and the number of spiders collected with prey (Ott 1984).

RESULTS

Spiders collected with prey.—During the survey, 188 spiders with prey were collected. Twenty-four of the specimens (13%) were obtained from the additional direct observations performed at the Herring Cove, Mt. Ararat, Mello 1, and Mello 2 bogs. On average, 3.3% (118/3590) of the spiders inspected at the four wild bogs and 2.1% (70/3419) of the spiders inspected at the three abandoned bogs had prey items (Table 1).

Sixty-one percent (115/188) of the spiders collected with prey were hunters and 39% (73/

Table 2.—Families of spiders collected with prey at wild and abandoned cranberry bogs in 1992.

	Abandoned bogs		Wild bogs		All bogs	
Spider family	*n*	%	*n*	%	*n*	%
Hunters (all)	47	67.1	68	57.6	115	61.2
Lycosidae	7	10.0	59	50.0	66	35.1
Oxyopidae	34	48.5	0	0	34	18.1
Salticidae	2	2.9	5	4.2	7	3.7
Thomisidae	2	2.9	4	3.4	6	3.2
Cubionidae	2	2.9	0	0	2	1.1
Web-builders (all)	23	32.9	50	42.4	73	38.8
Araneidae	4	5.7	37	31.4	41	21.8
Tetragnathidae	15	21.4	9	7.6	24	12.8
Linyphiidae	4	5.7	4	3.4	8	4.2
Total	70	100	118	100	188	100

Table 3.—Taxa of spiders and prey items collected in cranberry bogs in 1992. Order of prey: ARN = Araneae; COL = Collembola; DIP = Diptera; HOM = Homoptera; HYM = Hymenoptera; LEP = Lepidoptera; OTH = Others (including: Orthoptera, Psocoptera, Coleoptera, Neuroptera and Acari); TOT = Totals.

Spider family	Number of predation events							
	ARN	COL	DIP	HOM	HYM	LEP	OTH	TOT
Web-building spiders								
Araneidae								
Argiope spp.			2	2	3		2	9
Acanthepeira spp.	1							1
Epeira spp.			1					1
Mangora gibberosa (Hentz)			4	2	3	1	3	13
Neoscona arabesca (Walckenaer)			7	1	3			11
Neoscona pratensis (Hentz)			2		1			3
Neoscona spp.			1				1	2
Singa spp.			1					1
All species	1	0	18	5	10	1	6	41
Linyphiidae								
Ceratinops spp.		1						1
Frontinella spp.			1		2			3
Helophora spp.			1					1
Neriene clathrata (Sundevall)			1					1
Neriene variabilis (Banks)			1				1	2
All species	0	1	4	0	2	0	1	8
Tetragnathidae								
Tetragnatha laboriosa	0	3	15	4	0	1	1	24
All web-building spiders	1	4	37	9	12	2	8	73
Hunting spiders								
Lycosidae								
Arctosa spp.							1	1
Lycosa spp.	1							1
Pardosa floridana (Banks)	1	2	2	1				6
Pardosa milvina (Hentz)			1					1
Pardosa modica (Blackwell)							1	1
Pardosa moesta (Banks)	1		3			1		5
Pardosa saxatilis (Hentz)	5	12	22	5	2	3	2	51
All species	8	14	28	6	2	4	4	66
Oxyopidae								
Oxyopes salticus (Hentz)	0	12	8	4	2	3	5	34
Salticidae								
Evarcha flammata (Clerck)		1						1
Habronattus spp.	1							1
Metaphidippus spp.	1							1
Paraphidippus spp.		3	1					4
All species	2	4	1	0	0	0	0	7
Clubionidae								
Clubiona spp.		1						1
Catianeira spp.				1				1
All species	0	1	0	1	0	0	0	2
Thomisidae								
Philodromus spp.				1				1
Thanatus spp.	2			1			1	4
Xysticus spp.					1			1
All species	2	0	0	2	1	0	1	6
All hunting spiders	12	31	37	13	5	7	10	115
Totals	13	35	74	22	17	9	18	188

Table 4.—Seasonal variation in taxa of prey captured by spiders at four wild and three abandoned cranberry bogs in 1992. [a] Percentages = the number of insects from a specific order ÷ the total number of prey items captured by spiders during a month.

Month sampled (No. sampling events)	Orders of prey captured by spiders[a]														Total
	Araneae		Collembola		Diptera		Homoptera		Hymenoptera		Lepidoptera		Other		
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.
Abandoned bogs															
June (11)	1	3.5	10	34.4	9	31.0	2	6.9	1	3.5	1	3.5	5	17.2	29
July (8)	0	0	5	22.7	9	40.9	3	13.6	1	4.6	2	9.1	2	9.1	22
August (6)	1	5.3	4	21.0	6	31.6	4	21.0	3	15.8	1	5.3	0	2.0	19
Wild bogs															
June (9)	5	25.0	7	35.0	5	25.0	2	10.0	0	0.0	0	0.0	1	5.0	20
July (13)	4	6.4	8	12.9	29	46.8	5	8.1	7	11.3	4	6.4	5	8.1	62
August (10)	2	5.5	1	2.8	16	44.4	6	16.7	5	13.9	1	2.8	5	13.9	36
All Bogs															
Season totals (57)	13	6.9	35	18.6	74	39.4	22	11.7	17	9.0	9	4.8	18	9.6	188

188) were web-builders (Table 2). Of the hunting spiders, 87% (100/115) were from the families Lycosidae (wolf spiders) and Oxyopidae (lynx spiders). Spiders from the families Araneidae and Tetragnathidae (both orb weavers) made up 89% (65/73) of the web-builders with prey. Although eight families were represented in the survey, 88% (165/188) of all the predation events we witnessed involved lycosid, oxyopid, araneid, or tetragnathid spiders.

The dominant families of hunters and web builders collected with prey differed between the wild and abandoned bogs. At the wild bogs, 81% (96/118) were lycosids and araneids, while at abandoned bogs, 70% (49/70) were oxyopids and tetragnathids. Lycosids and araneids were captured with prey and observed in high numbers at all of the wild bogs. All of the oxyopids captured with prey were from the abandoned Mello 1 and 2 bogs, although the presence of oxyopids at Windmill was noted during collection outings. In addition, 13 of the 15 tetragnathids with prey from abandoned bogs were obtained at the Windmill bog.

In total, 24 genera of spiders with arthropod prey from 11 orders were collected and identified during the survey (Table 3). Three species (*Pardosa saxatilis* Hentz (Lycosidae), *Oxyopes salticus* Hentz (Oxyopidae), and *Tetragnatha laboriosa* Hentz (Tetragnathidae)) represented 58% (109/188) of all specimens collected with prey. Sixty-seven percent (34/51) of the prey recovered from *P. saxatilis* were Diptera (22/51) or Collembola (12/51); another 20% (10/51) were identified as Homoptera (5/51) and Araneae (5/51). Collembolans (35%, 12/34) and dipterans(24%, 8/34) were the dominant prey captured by *O. salticus,* and no predation on spiders by this species was observed during thesurvey. The majority of *T. laboriosa* with prey possessed chironomids (63%, 15/24) or homopterans (17%, 4/24). In addition to these three species, another 27% (51/188) of the spiders with prey were identified as various species of *Pardosa, Mangora* (Araneidae), *Neoscona* (Araneidae), and *Argiope* (Araneidae).

Thirty-nine percent (74/188) of the arthropods recovered from the chelicerae of all spiders captured with prey were dipterans. Small flies from the family Chironomidae represented 51% (37/73) of all prey captured by web building species and 32%(37/115) captured by hunting species. Other orders frequently possessed by the web-building spiders included the Hymenoptera (16%, 12/73) and Homoptera (12%, 9/73). In addition to Diptera, the most common prey of spiders in the hunter guild were Collembola (27%, 31/115), Homoptera (11%, 13/115) and Araneae(10%, 12/115).

During the months that sampling was conducted, fluctuations in the proportions of arthropod orders possessed as prey by spiders

Table 5.—Seasonal variation in potential prey at four wild and three abandoned cranberry bogs in 1992. Potential prey orders: Percentages = the number of insects from a specific order ÷ the total number of potential prey collected during a month.

Month sampled (No. sampling events)	Araneae		Collembola		Diptera	
	No.	%	No.	%	No.	%
Abandoned bogs						
June (8)	150	3.9	1534	40.3	1417	37.3
July (5)	392	7.7	2558	50.4	558	11.0
August (4)	942	30.0	1267	40.3	456	14.5
Wild bogs						
June (7)	99	2.7	2143	59.1	664	18.3
July (11)	798	11.4	1944	27.7	1801	25.7
August (7)	550	22.3	516	20.9	600	24.4
All Bogs						
Season totals (42)	2931	11.7	9962	39.6	5496	21.9

at the wild and abandoned bogs were evident (Table 4). Between June–August at the wild and abandoned bogs, the proportion of homopteran and hymenopteran prey captured by spiders increased, while the proportion of collembolan prey taken decreased. During the same interval, the proportion of the total prey from the orders Lepidoptera and Diptera was greatest in July. Araneid prey items comprised a larger proportion of the total prey taken by spiders at the wild bogs(from 6–25%) than at the abandoned bogs (from 0–5.3%) throughout the study.

Potential prey.—Dvac® samples taken during June, July, and August showed fluctuations in the abundance of potential prey (arthropods available to foraging spiders). The number of arthropods collected per sample was greatest during July at both wild and abandoned bogs (Table 5).

Collembola were the most abundant potential prey at the abandoned sites, comprising 40–50% of all arthropods collected each month. In addition, the emergence of chironomids in June, adult Lepidoptera in July, and oxyopid spiderlings in August was reflected in the composition of the samples from the abandoned bogs.

At the wild sites, the proportion of Collembola steadily declined from 59% (2143/3628) of the total potential prey in June, to just 21% (516/2464) in August. During July, increased numbers of arthropods from the orders Araneae, Diptera, Homoptera, and Hymenoptera were evident in the samples from the wild sites. Of the total potential prey present in Dvac® samples from all wild and abandoned sites throughout the survey, the most abundant orders were (in descending order) Collembola, Diptera, Araneae and Hymenoptera.

Comparison of collection methods.—Of the two collection methods we employed in the cranberry system, direct observation was generally more effective for capturing spiders with prey than sweep netting. Although the mean number of spiders inspected using the two methods was similar over all seven sites surveyed, the mean number of spiders collected with prey was greater using the direct observation method ($P = 0.0001$, Wilcoxon signed rank test) (Table 6).

During the field trial conducted in 1993, the protocol for direct observation used in the 1992 survey resulted in both a greater mean number of spiders inspected ($P = 0.001$, Wilcoxon signed rank test) and collected with prey ($P = 0.003$, Wilcoxon signed rank test) than the "drunkard's walk" method (Table 7).

DISCUSSION

Spiders collected with prey.—Over all sites, approximately 2.7% (188/7009) of the spiders that we inspected possessed prey. In the literature, the percentage of hunting spiders collected while feeding ranges from 1.4–8.3% (Nyffeler et al. 1987b, 1989; Young 1989), while <10%–12% has been reported for web-builders (Nyffeler et al. 1989; LeSar

Table 5.—Extended.

Homoptera		Hymenoptera		Lepidoptera		Other		Total
No.	%	No.	%	No.	%	No.	%	No.
136	3.6	448	11.8	33	0.9	83	2.2	3801
204	4.0	565	11.1	633	12.5	170	3.3	5080
80	2.6	261	8.3	72	2.3	64	2.0	3142
228	6.3	357	9.8	21	0.6	116	3.2	3628
786	11.2	932	13.3	190	2.7	557	8.0	7008
166	6.7	295	12.0	221	9.0	116	4.7	2464
1600	6.4	2858	11.4	1170	4.6	1106	4.4	25 123

& Unzicker 1978). Although collecting technique, vegetational architecture, spider species, potential prey and several other factors varied among the studies, the average percent of spiders with prey in unmanaged cranberry systems falls within the range of that found in other systems.

Of the total spider fauna found in field crops grown in the United States, 56% are estimated to be hunting species and 44% web-building species (Young & Edwards 1990). Surveys performed in alfalfa, peanuts, rice, and cotton cite percentages ranging from 42–93 for hunting spiders and 17–58 for web-builders (Wheeler 1973; Agnew & Smith 1989; Heiss & Meisch 1985; Whitcomb et al. 1963). We found the proportions of spider types collected with prey in cranberries to be similar to these other crops, i.e., 61% were hunting species and 39% web-building species. Though the diversity of species was not determined, it is likely that these values reflect the general composition of spider types present on cranberry bogs.

The feeding trends of spiders collected with prey at wild and abandoned cranberry bogs indicate that many of the web-building and hunting species present have a varied diet that is dominated by adult dipterans. Of the 188 spiders collected with prey, 51% of all web-builders and 32% of all hunters possessed dipteran prey. Relatively high proportions of Diptera (up to 77.8% of all prey captured) have also been reported in the diets of many web-building and hunting spiders in soybean, cotton, wheat field, alfalfa, and grassland ecosystems (Nyffeler et al. 1994). In general, spiders collected with prey in cranberries possessed arthropods of types located in the microhabitat where the spider's foraging activity was concentrated; hunters possessed prey from the ground and the cranberry vine strata, web-builders prey from the vine and tall vegetation strata.

Prey data for hunting spiders in many systems indicate that although a variety of arthropod taxa are accepted, the groups most commonly captured include Collembola, Diptera, Heteroptera and Araneae (Edgar 1969; Hallander 1970; Yeargan 1975; Nyffeler et al. 1992, 1994). In addition to dipterans, most hunting spiders in cranberries possessed prey from orders located primarily on the ground or in the vines of bog, specifically, Collembola (27%), leafhoppers (11%), and immature spiders (10%).

The species of hunting spiders most frequently collected with prey in cranberry were *Pardosa saxatilis* Hentz and *Oxyopes salticus* Hentz. *P. saxatilis* was collected with a wide range of prey that was dominated by Diptera and Collembola, but occasionally included species of leafhoppers that vector cranberry false blossom disease and Lepidoptera whose larvae are foliar pests in the cranberry system. Yeargan (1975) observed that, despite an abundance of lepidopterans in alfalfa, the diet of the lycosid *Pardosa ramulosa* McCook

Table 6.—Comparison of the mean number of spiders inspected and collected with prey using direct observation and sweep net methods in 1992. [a] Spiders with prey collected during additional visits to sites were not used in comparison calculations. n = 21 hours for direct observations and n = 210 sets of five sweeps for sweepnet samples at each bog. [b] Significantly more spiders with prey were collected using the direct observation method (P = 0.0001, Wilcoxon signed rank test).

		Mean number ± SE	
Bog	Method used[a]	Inspected	Collected with prey
High Head	Direct observation	25.0 ± 2.7	1.6 ± 0.4
	Sweepnetting	20.0 ± 2.1	0.1 ± 0.1
Herring Cove	Direct observation	24.7 ± 1.9	0.8 ± 0.2
	Sweepnetting	19.0 ± 2.4	0
Mt. Ararat	Direct observation	24.2 ± 2.2	1.2 ± 0.3
	Sweepnetting	14.7 ± 1.4	0
Sandy Neck	Direct observation	26.2 ± 3.9	1.0 ± 0.2
	Sweepnetting	7.7 ± 1.3	0
Mello 1	Direct observation	21.7 ± 2.2	0.7 ± 0.2
	Sweepnetting	19.0 ± 3.2	0.2 ± 0.2
Mello 2	Direct observation	32.8 ± 4.0	0.6 ± 0.2
	Sweepnetting	78.7 ± 37.9	0.4 ± 0.1
Windmill	Direct observation	17.8 ± 2.3	0.7 ± 0.2
	Sweepnetting	19.3 ± 3.2	0.2 ± 0.1
All bogs	Direct observation	24.6 ± 1.1	1.0 ± 0.1[b]
	Sweepnetting	25.5 ± 5.7	0.1 ± 0.0

consisted primarily of prey from the orders Homoptera, Diptera, and Araneae. Yeargan concluded that the predation exhibited by *P. ramulosa* may have been due to the rarity of encounters with Lepidoptera, which were located in the foliage above areas where the spiders most often foraged, and to attractiveness of the sudden movements often made by homopteran and dipteran prey. Although lepidoptera were scarce in the bogs we sampled, these factors may have affected the prey selection we observed for *P. saxatilis*.

Predation of spiders by oxyopids has been reported in several surveys conducted in cotton and wooley croton, *Croton capitatus* Michaux, in Texas (Nyffeler et al. 1987a, 1987b, 1992). However, Lockley & Young (1987) noted a conspicuous lack of spiders possessed as prey by *O. salticus* in cotton in Mississippi, USA. Our data on the feeding behavior of *O.*

Table 7.—Comparison of the mean number of spiders inspected and collected with prey using the "drunkard's walk" and 1992 direct observation methods. [a] n = 8 h for each method at each site. Significantly more spiders were inspected[b] (P = 0.001, Wilcoxon signed rank) and collected with prey[c] (P = 0.003, Wilcoxon signed rank) using the direct observation technique.

		Mean number ± SE	
Bog	Method used[a]	Inspected	Collected with prey
Herring Cove	Drunkard's walk	9.5 ± 3.0	0.3 ± 0.3
	Direct observation	54.8 ± 7.3	2.8 ± 0.5
Mt. Ararat	Drunkard's walk	22.8 ± 2.1	0.5 ± 0.3
	Direct observation	50.0 ± 5.6	3.5 ± 1.5
Sandy Neck	Drunkard's walk	8.5 ± 3.5	0.5 ± 0.5
	Direct observation	40.5 ± 7.2	3.3 ± 2.0
All bogs	Drunkard's walk	13.6 ± 2.5	0.4 ± 0.2
	Direct observation	48.4 ± 4.0[b]	3.2 ± 0.8[c]

salticus in abandoned cranberry bogs concurred with the latter findings for unknown reason(s), but which may have involved the availability of more easily captured prey items.

Studies of orb-weaving spiders (Araneidae and Tetragnathidae) in temperate regions have shown that most species capture Homoptera, Diptera, and small parasitic Hymenoptera in their webs (Nentwig 1987; Culin & Yeargan 1982; Provencher & Coderre 1987). In addition, large orb-weavers (*Argiope* spp.) may feed on aculeate Hymenoptera, grasshoppers, and various other "difficult" prey (Nentwig 1985; Nyffeler et al. 1987c, 1989, 1991). Our data show that orb spiders capture winged prey, predominantly Diptera, Hymenoptera and Homoptera, flying between cranberry vines and tall vegetation in bogs. Though uncommon in our study, several large-bodied Hymenoptera and Orthoptera were captured by females of the genus *Argiope* in late August as the spiders approached maturity. The majority of prey captured by species of sheetweb spiders (Linyphiidae) were from the same orders as those captured by orb-weavers.

The web-builder *Tetragnatha laboriosa* Hentz, one of the most frequently occurring spider species in field crops in the USA (Young & Edwards 1990), has been shown to commonly capture heteropteran and dipteran prey in cotton and soybean systems (LeSar & Unzicker 1978; Culin & Yeargan 1982; Nyffeler et al. 1989). In our survey of unmanaged cranberry bogs, *T. laboriosa* was the species of web-building spider most frequently observed with prey. The orders of prey possessed most often, Diptera and Homoptera, were consistent with the dominant arthropod groups reported for this species in the agricultural systems previously mentioned.

Spiders are considered by many to be generalist predators that capture the prey species that are most abundant, and thus most often encountered, in their environment (Turnbull 1960; Riechert & Lockley 1984; Wise 1993). Comparison between the proportion of prey captured by spiders and frequencies of potential prey in cranberry bogs indicates that spider predation is influenced by prey abundance (Tables 4 and 5). Although the numbers of spiders collected with prey were low, the number and type of prey possessed by spiders fluctuated with the relative abundance of potential prey as captured in Dvac® samples, for most of the arthropod orders present in the system.

Foliage-feeding lepidopteran larvae and adult cranberry weevils (*Anthonomus musculus* Say) are the primary pest insects found in commercial cranberry bogs. Of the 13 spiders captured with lepidopteran prey in non-commercial bogs, five of the prey items were larvae. Two spiders were collected with coleopteran prey items during the study; however, neither was a cranberry weevil. In sum, our data indicate that few spiders in non-commercial cranberry bogs capture pest insects such as lepidopteran larvae or weevils. This suggests that spiders with similar predation behavior in commercial bogs may not have a very high impact on insect pests, particularly low density populations such as were present in the non-commercial systems.

Comparison of collection methods.— Over the seven-week period of this study, direct observation was more effective than sweepnetting in collecting spiders with prey. Spiders collected using sweepnets were often damaged and rarely possessed prey. Both injury to the spiders and absence of prey was most likely the result of the sweeping motion and tumbling contents of the net. Under such conditions, it is likely that spiders entering a sweepnet with prey in their mouth parts responded by releasing their prey. Prey may have also been released by spiders as the sweep samples were emptied into the dish pan and inspected.

Mean numbers of spiders inspected and collected with prey during 1993 show that the direct observation method used in 1992 was also more effective than the "drunkard's walk" method in the cranberry system, despite the successful use of the latter method in other systems (S.E. Riechert, pers. comm.). Unlike many row crops, the cranberry bogs we surveyed were covered in dense layers of vine with little exposed substrate. Hunting spiders were only visible when they were resting or actively moving on the uppermost layer of cranberry vine. Web-building spiders often positioned themselves in grasses and shrubs above the vines where they were visible to observers. Although they were easily spotted, there were not many present in any given area of bog. Given such circumstances, the probability of locating a hunting or web-building

spider may have been improved by using the direct observation method because of the increased proportion of bog area searched by experimenters.

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